

NATIONAL ADVISORY COMMITTEE  
FOR AERONAUTICS

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TECHNICAL NOTES

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS.

TO: *Mr. Luskatt*

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No. 193

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HIGH ALTITUDE FLYING.

By Paul B. King and Thomas Carroll,  
Langley Memorial Aeronautical Laboratory.

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Early in the flight work incidental to the development of supercharged engines at the Committee's Laboratory at Langley Field, we were somewhat astonished to find that the information concerning this branch of flying was very meager. As our experience developed, we were further surprised to find that even this fragmentary information was unreliable; that it was apparently collected rather for its news value than for its value as scientific data.

The effect of high altitude or low atmospheric pressure upon the operation of an engine was theoretically well known. The effect of the low pressure and lack of oxygen, and of the very low temperatures upon the pilot and likewise upon the performance of the airplane itself was not so well known. There was also a divergence of opinion concerning the use of oxygen apparatus according to the previous experience of American and British practice.

The use or abuse of the oxygen equipment appears to have the greatest influence upon the physical comfort and efficiency of the pilot while engaged in flights above 15,000 feet. We consequently will mention that important feature first.

It is of the greatest importance that the oxygen should be of the purest grade and thoroughly dried. The drying is important because moisture may collect in the tubes or valves and is apt to freeze, causing a stoppage. Care should be taken that oil is excluded from all internal parts of the apparatus as the presence of even a minute quantity of oil, if inhaled, is nauseating.

Automatic oxygen control we learned to have been unsatisfactory and we have never attempted its use. The simple manual control which we adopted has always functioned perfectly and we have never contemplated a change. This consists of a conventional hookup of five bottles, each of three liter capacity and under 1500 pounds pressure, connected to a common header with a single lead to a high pressure gage and a manually operated reducing valve. This valve is of a type in common use with oxy-acetylene welding outfits. From the valve a lead is carried to a flow meter graduated in "liters per minute" and thence directly by a rubber tube to the face mask. The mask is of rubberized fabric, fur lined about the edging, covering the entire face from the bridge of the nose down to well under the chin. The intake is through a tube just over the nostrils and at the chin there is a simple rubber flap exhaust valve. A sixth oxygen bottle is provided for emergency use controlled only by the bottle valve and having another rubber tube attached.

A difference of opinion exists as to the proper altitude to begin the use of oxygen. We believe that it should be taken

immediately the slightest need is felt and in ordinary cases preferably at and above 15,000 feet and certainly not later than 18,000 feet. No advantage can be gained by delaying its use as such delay can only accomplish a drain upon the body reserve inducing fatigue both during and following the flight.

Concerning the amount of oxygen to be taken as indicated by the flowmeter, we suggest that from 2.7 to 3 liters per minute be used up to 25,000 feet, gradually increasing above that altitude to  $3\frac{1}{2}$  or 4 liters per minute with a possible maximum of  $4\frac{1}{2}$  liters at 35,000 feet. The individual must determine for himself what the requirements of his system are; the foregoing is merely a guide indicated from our experience as the normal requirement. The effects of too little oxygen will be immediately distinguished in dizziness, drowsiness and impaired vision. Of too great an amount the effects will unfortunately not be noticed until a day or two later when it will be evidenced by sore lungs.

In descending it is best to continue the use of oxygen to a fairly low altitude; we would recommend to 10,000 feet. This will alleviate the uncomfortable feeling and deafness usually accompanying the descent. On the descent a decrease in the flow rate should be made corresponding to the increase in rate on the climb as indicated by the flowmeter.

In the operation of the control valve it will be noted that as the altitude increases, and due to the drop in external pressure, the flow will tend to increase at too rapid a rate and this

must be checked by a manipulation of the valve. On the descent the contrariwise will be found.

We have noticed that the best work can be done more comfortably when a heavy diet and any appreciable amount of liquids are refrained from on the day of the flight.

As to the effects of the extreme cold we have but little trouble. A fur-lined leather flying suit together with fleece-lined moccasins of the usual Air Service style constituted the clothing equipment used. These were not of the electrically heated type, nor was the necessity for such heating felt. The ordinary fur-lined helmet was augmented by an additional helmet, somewhat larger, fitted over the first. Gauntlet gloves of the type having the index finger separate and the remaining three fingers in one were used because it was necessary for the pilot to write observation data during the flights. A chamois face mask was tried but was discarded as unnecessary since the oxygen mask covered all of the lower face comfortably. Goggles No. 6 were used and were quite satisfactory although a second pair was carried in the event of fogging and freezing. Part of the ordinary clothing was discarded and a suit of very heavy silk underwear substituted. This added warmth and was less bulky. Two pairs of heavy woolen socks were worn without shoes other than the moccasins. This outfit was found to be quite satisfactory and no discomfort was felt with the exception of the fingers. Ordinarily, were it not required to use the hands other than in

piloting, a heavy double mitten would be preferable. We are now attempting the use of electrically heated grips on the controls but since the work is temporarily stopped during changes in the equipment we cannot report their efficacy.

It is obviously wiser to refrain from any physical exertion particularly during warm weather just prior to the flight, since if the body is damp with perspiration the effect of the low temperature will be the greater. It is better to wait until the body has cooled and damp clothing removed if necessary.

We have experienced no after effects from this nature of work nor from the use of oxygen. There has been no extraordinary fatigue following any flight and the same pilot has many times made other flights of more ordinary character within a few hours after the completion of a high altitude flight. Even two of these flights have been made on the same day and a number have been made on successive days without deleterious effect. Immediately following a number of these flights, the pilot involved has submitted to a physical examination by a physician and no after effect has been noted.

Likewise, we have been unable to note any effect upon the system due to the low atmospheric pressure, at least none that is not corrected by the proper use of oxygen. In fact, we would impress the point that the proper and careful use of oxygen eliminates all of the unpleasant and unusual elements of the work. Most of the uncomfortable feeling is occasioned from psychological

causes rather than physiological. Even the pilot of experience is prone to favor his imagination in the monotony and lonesomeness of high altitude flight. Peculiarly, even this difficulty is remedied by the proper use of oxygen.

We believe that the foregoing encompasses all of the hazards together with their remedies so far as the effect upon the physical condition of the pilot is concerned.

Of the airplane itself we have found that the low temperature has annoying effect upon the interplane and control wires due to their contraction, and upon the control bearing surfaces due to coagulation of the lubricant. Our remedy for this was to rig the wires loosely and to thoroughly clean the bearings and use a very thin oil.

The behavior of the airplane in the rarefied atmosphere of 30,000 feet and above is quite normal. Stalling and the recovery from the stall, so far as we can observe, is the same as at lower altitudes.

We have encountered no prevailing wind of high velocity estimating the maximum at sixty miles per hour and the average in the neighborhood of forty.

Our greatest worry in regard to the prevailing wind is a condition that would probably only exist on the east coast. That is, that since the prevailing wind is from west to east, that a parachute descent would undoubtedly carry one out to sea unless the flight is carried well inland.

In general we now feel that there is no reason why this work may not be taken up without the timidity or anxiety to which we must confess in our initial attempts. We trust that this information will be of value to those who in the future will enter this work as a new field.